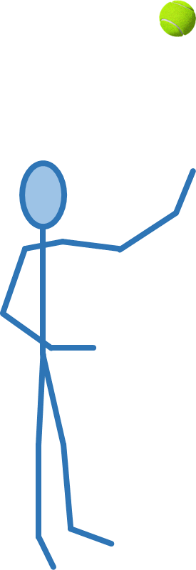
**Accelerating ball**

Albert throws a ball straight up in the air.

As it rises, it slows down.

And as it falls it speeds up.



Force on ball, F = 0.6 N

Mass of ball, m = 0.06 kg

Acceleration, a = ? m/s2

force = mass × acceleration

**F = m × a**

For each part of the throw, what is the acceleration of the ball?

*With a ruler, draw a line connecting each part of the ball’s path to its acceleration at that point.*

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Falling ball

Rising ball

Highest point

10 m/s2 upwards

0 m/s2

10 m/s2 downwards

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*Physics > Big idea PFM: Forces and motion > Topic PFM6: Forces make things change > Key concept PFM6.2: Force, mass and acceleration*

|  |
| --- |
| **Diagnostic question** |
| **Accelerating ball** |

**Overview**

|  |  |
| --- | --- |
| Learning focus: | The acceleration of an object is proportional to the resultant force acting on it and inversely proportional to its mass. An object accelerates in the direction of the resultant force acting on it. |
| Observable learning outcome: | Use the equation F = m x a to determine and explain the motion of falling objects. |
| Question type: | Linking ideas |
| Key words: | Force, mass, acceleration |

**What does the research say?**

Redish and Kuo (2015)suggest for many students, the first step in physics calculations needs to be highlighting the physical meaning, which can later be tied to the formal mathematical laws. This can help students by giving meaning to equations, so analysis of problems is no longer a ‘brittle rote procedure’. It can also lead to conceptual short cuts that enable students to access more challenging problems. For many experienced physicists, physical meaning is gained by beginning with the mathematical relations that come easily to them, but their strategy is less effective for many learners.

Boohan (2016)describes four steps to rearranging formulae involving multiplication and division: first swap sides if necessary, so the variable to be made the subject of the formula is on the left; then multiply or divide both sides by the same variable(s) to leave the subject of the equation on its own; the third step is to cancel out these variables on the left-hand side. Finally, students should always check that the meaning of the new equation makes sense. Through this process, confident students might take shortcuts, but Boohan recommends that teaching always emphasises an understanding of the principles by carrying out all the steps.

When thinking about forces and motion, students treat motion in a horizontal plane and motion in a vertical plane differently (Lemmer, 2013). Some students do not see weight as a force, believing that gravity is the natural tendency of things to fall. Students may believe that when objects rise and fall in a gravitational field, upward and downward motions need to be explained differently (Twigger et al., 1994).

**Ways to use this question**

This task is intended for discussion in pairs or small groups. It is best done as a pencil and paper exercise.

Students should follow the instructions on the worksheet. Listening in to the conversations of each group will often give you insights into how your students are thinking. Each member of a group should be able to report back to the class.

Feedback from each group can be used, with careful teacher questioning, to bring out a clear description or explanation of the science.

*Differentiation*

The quality of the discussions can be improved with a careful selection of groups; or by allocating specific roles to students in each group. For example, you may choose to select a student with strong prior knowledge as the scribe, and forbid them from contributing any of their own answers. They may question the others and only write down what they have been told. This strategy encourages contributions from more members of each group.

NB in any class, small group discussions typically improve over time and a persistence with this strategy is often very successful in the medium to long term.

**Expected answers**

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Falling ball

Rising ball

Highest point

10 m/s2 upwards

0 m/s2

10 m/s2 downwards

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**How to respond - what next?**

The force acting on the ball is equal to the force of gravity, if air resistance is ignored. This force acts downwards and accelerates the ball in this direction. Rearranging the equation and substituting the values provided will give a value of 10, and this does not change no matter where the ball is during its flight.

Rising ball: it is common for students to have the misunderstanding that acceleration acts in the direction in which an object is moving – even if it is slowing down.

Highest point: the ball is momentarily stationary at this point, and students often have the misunderstanding that this means that the force acting on it must be balanced. In this instance, there is no upwards force, so the logical conclusion is that no forces are acting. Students selecting this option are perhaps not thinking of gravity as a force, or may not have thought through the consequence of their choice, which *makes* the ball weightless.

If students have misunderstandings about using the equation F = m x a to determine and explain the motion of falling objects, it can help to talk through each situation with the class. Very useful questions to ask, for each point of the balls motion, are ‘what will happen to it next?’ and ‘which way will a force need to act in order to cause that change?’.

The following BEST ‘response activity’ could be used in follow-up to this diagnostic question:

* Response activity: Free-fall

**Acknowledgments**

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Images: Peter Fairhurst (UYSEG).

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